EXECUTIVE SUMMARY

An alluvial fan is an accumulation of river or stream (alluvial) sediments that forms a sloping landform, shaped like an open fan or segment of a cone. Alluvial fans typically form where streams emerge from hill country onto a valley floor. Of the hazards associated with alluvial fans, the most serious are fast-moving sediment-laden floods and slurry-like flows of debris. Such floods and flows may commonly break out from existing stream channels and forge new, sometimes unexpected, paths. Fan sediment-laden floods or flows may be damaging or destructive to anything in their paths, and pose a threat of injury or death to people. Less serious hazards include sediment build-up, which may cause damage to productive land, crops or various types of infrastructure, such as water supplies or roads.

The Otago Regional Council is leading the 'Otago Alluvial Fans Project', which aims to assess the nature and extent of hazards, and potential impacts on communities, associated with alluvial fans in Otago. The rationale of the project is that by improving our knowledge of alluvial fans, their associated hazards may be able to be mitigated in an appropriate manner.

Initiated in 2006, a general review of the hazards associated with alluvial fans (Opus report 'Otago Alluvial Fans Project', issued 2009) included a set of regional maps of alluvial fans in Otago, compiled largely from pre-existing data. Following consultation with Otago's territorial authorities to identify which areas of Otago would benefit most from additional information on alluvial fans, Otago Regional Council commissioned supplementary work on alluvial fans in selected areas of Otago, which is the subject of this report. The aims of this work are to:

- provide a more in-depth picture of the nature and characteristics of alluvial fans in these areas, set within a regional perspective of alluvial fan active processes;
- develop methods for the mapping and classification of Otago's alluvial fans, drawing on scientific (landform) evidence of flooding and sedimentation histories, and;
- produce an alluvial fan landform map data set for the selected investigation areas.

The report documents the methods and results of this work. Like the earlier phase of mapping, the alluvial fan map has been done using Geographic Information System (GIS) computer methods. The in-depth picture of the alluvial fans in each selected assessment area is conveyed by an 'information sheet' for each area, accompanied by maps. It is anticipated that the data sets accompanying this report will provide a foundation for the assessments of alluvial fan hazards. The data sets may also assist territorial authorities in the refinement of district plans and in guiding community and infrastructural developments.

An alluvial fan system comprises three major components: (i) its catchment; (ii) its stream and fan; and (iii) its downstream end (toe). Conditions in a catchment determine the quantities of sediment that are delivered to its fan, whereas conditions at the fan toe dictate whether the sediment is able to be taken away from the fan system. Accordingly, the maps prepared as part of the supplementary work include, in addition to the fans themselves, the catchments upstream of the fans, as well as what lies at and just beyond the toes of the fans.

The mapping relied largely upon interpretation of aerial photos, with selected field-checks. The fan mapping is based on landforms and the maturity of soils developed on the fans. Very

young (‘immature’) soils are easily recognisable by their appearance. The maps distinguish fan surfaces that have experienced flood sedimentation in the past few hundred years (with ‘immature’ soils, nominally less than 300 years old) from older fan surfaces (‘mature’ soils). This mapping approach provides a scientifically-based assessment of recent fan activity.

Catchments are subdivided according to an interpretation of how stable their slopes have been. Areas at and beyond fan toes were mapped according to their origin and activity (e.g. is there a river which can carry away sediment from the fan?). Additional information gathered included: (i) the nature of the boundaries between different landforms (e.g. terrace edges); (ii) the nature and activity of stream channels on the fans; and (iii) points of information such as the depths of channels.

The physical characteristics of alluvial fans and their settings in the landscape provide insights to the types of behaviour (and hazards) that can be expected. The dominant factor controlling the type of fan is the balance between: (i) sediment supply from a catchment; (ii) sediment transport down a fan by its stream; and (iii) sediment removal at the toe of a fan. On this basis, four types of fan are identified: aggradational (sediment builds up on the fan); equilibrium (sediment is transported down the fan and removed from its toe); degradational (sediment is eroded from the fan) and terraced (repeated cycles of aggradation and degradation have terraced the fan). Recognition of these behavioural types is expected to assist in identifying and assessing the nature and severity of fan hazards as part of future site-specific investigations. An aggradational fan is the most susceptible to channel break-out and flooding, whereas terraced fans may have areas that lie well above present flood levels.

The Otago region spans a wide range of landscape settings. From the province’s northwest margin in the Southern Alps, the wet mountain climate areas give way gradually to the semi-arid ranges and basins of Central Otago, which in turn grade out to the humid hills, valleys, terraces and plains of coastal Otago. These contrasts, plus the influences of geology, and of river, lake or coastal processes, are expressed in the character of the region’s alluvial fans:

- In the wet mountains of northwest Otago (including Makarora and Glenorchy), the landscapes are young, precipitation is large and rates of erosion and fan-building are substantial. Fans are mostly aggradational, although other types are present, depending on the proximity of valley-floor rivers to the fan toes. There are many historic examples of damaging or destructive fan-flooding events.

- The ranges and basins of inland Otago encompass the selected assessment areas of Hawea, Wanaka, Luggate, Queenstown, Kingston and Kawarau (to the west), Cromwell and Alexandra (centre) and Roxburgh, Tapanui and Middlemarch (south and east). The landscapes are old and rates of erosion and fan-building are generally slow. All types of fans are present, with terraced fans particularly common close to the Clutha River. There are several historic examples of fan-flooding events.

- The hills, valleys and plains of coastal Otago (including the Oamaru assessment area) comprise a mix of old and young landscapes. Fans have built out onto terraces or into valleys, bays and harbours, and all types of fan are represented. Historic records of fan-flooding include instances where landslides in the catchments have sent damaging debris flows down onto the fans.

The report also outlines suggestions for how the supplementary mapping and other information could be used to guide enquiries into site-specific hazard issues.